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L. O. HOWARD, Chief

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THE GRAPE LEAF-FOLDER.

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INTRODUCTION.

The grape leaf-folder, *Desmia funeralis* Hübn. (family Pyralidae) has long been known as a pest of grapevines. Since 1885 the injury inflicted by the larva has been described frequently, and different remedial measures have been suggested. However, the insect has not been the subject of very careful study, and references to it in literature are mostly in the form of short notes in farm and horticultural journals.

Certain facts concerning the life history and habits of this insect were obtained during two seasons' observations in the vicinity of the city of Washington.

HISTORY.

The grape leaf-folder first appeared in literature in 1796, when it was figured by Hübner (1)[1] under the name of *Pyralis funeralis*. Switzerland was given for the locality, which was evidently a mistake, as pointed out by Guenée (5, p. 190) in 1854. Later Hübner (2) placed the species in the genus Anania.

In 1832 Westwood (4) established the genus Desmia and placed in it the species *maculalis*, including as a probable synonym *Botys*

[1] Numbers in parenthesis refer to "Literature cited," p. 13.

bicolor Swainson (3), which he considers the female of *maculalis*. In 1854 Guenée (5, p. 189) included in the genus Desmia descriptions of both *maculalis* and Hübner's *funeralis*, the latter being taken from Hübner's original figure of the species. Five years later Walker (7) reduced *Desmia maculalis* Westw. to the rank of a synonym, naturally giving *Desmia funeralis* Hübn. priority.

Following is the synonymy of the species:

Desmia funeralis.

Pyralis funeralis Hübn., Pyral. f. 103, 1796.
Anania funeralis Hübn., Verz. Schm. 360, 3449.
Botys bicolor ? Swain., Zool. Illustr. II, pl. 77. 1821–2.
Desmia maculalis Westw., Mag. Zool. Class IX, pl. 2. 1832.
Desmia funeralis (Hübn.) Guen., Delt. et Pyral. No. 124, p. 190. 1854.

The history of the grape leaf-folder from an economic standpoint began in 1855 with Glover's (6, p. 78) description of the injury inflicted upon grapevines under glass. The remedy suggested, which has been recommended most often since, was hand-picking and trampling under foot of the folded leaves, thus killing the larvæ. Glover had specimens and records of injury from the District of Columbia, Columbia, S. C., and Atlanta, Ga.

In 1868 Riley (9) gave a short description of the insect and its work and stated that it was of common occurrence in Illinois.

Saunders (10), in his "Insects Injurious to the Grape," mentions having met with a few specimens of the grape leaf-folder in Ontario, Canada.

In 1897 Hoy (11) stated that Desmia, in Wisconsin, was a great pest among the vineyards.

Bulletin 4 of the South Carolina Agricultural Experiment Station (12) states that the insect is very abundant throughout the Southern States; the damage wrought by it, however, is slight. The usual remedial measure, that of crushing the larvæ within the folded leaves, is recommended.

In the same year Woodworth (13) writes that *Desmia funeralis* is an important pest in Arkansas. Here we find the most complete account of the life history to date. Six species of insects parasitic on the grape leaf-folder were obtained, and the author advises keeping the infested leaves, after picking, in a finely screened box in order to afford the parasites an opportunity to escape, but yet retain the hosts, and thus materially aid in the natural control of the pest.

The same author (14, p. 71), two years later, informs us that the station vineyard at the Arkansas Agricultural Experiment Station is badly infested. He notes a difference in the amount of injury inflicted upon different varieties of grape.

Riley (16) again refers to the insect, quoting correspondence showing the leaf-folder to be common in Texas, and Troop (15, p. 74) re-

cords the species in limited numbers in Indiana. The latter writer recommends gathering and burning all dead leaves.

Marlatt (17) gives a short account of the insect's life history and recommends the use of an arsenical spray as well as hand picking and clean culture as combative measures.

Smith (19, p. 459) lists *Desmia funeralis* from several localities in New Jersey, and Bogue (18) records two broods of the insect in Oklahoma. Picking the folded leaves is recommended, together with rearing the parasites and allowing them to escape.

Unusual injury by the pest in various localities in Georgia is recorded in the Annual Report of the Georgia Agricultural Experiment Station (20).

Webster and Newell (21), in Ohio, reared the insects, together with a parasite, *Habrobracon gelechiae*, from grape leaves. Washburn (23) records the insect in Minnesota and recommends hand picking. Pettit (24, p. 322) refers to its presence in Michigan.

Quaintance (25) gives a short sketch of the life history of the grape leaf-folder, with treatment, the latter consisting of spraying, hand picking, and clean culture. Vines sprayed with arsenicals for other insects will not be troubled by the leaf-folder.

Essig (26) has recently treated of the pest in California, giving a short account of the life history of the species; arsenical spraying is recommended as a remedy, although the insect has never become economically important in the Far West.

DISTRIBUTION.

Walker (7) gives the distribution of *Desmia funeralis* as United States and Nova Scotia to Orillia, Ontario Province, Canada. According to Marlatt (17) it occurs from New England southward to Florida, and westward at least to the Rocky Mountains. The Atlantic States is given as its range in Dyar's list (21).

In California, according to Essig (26), it occurs in the central part of the State, being most commonly found in the Sacramento and San Joaquin valleys.

It will be seen from the above and from the references given under the history of the species, that *Desmia funeralis* is widely distributed in the United States, covering doubtless all regions where the wild or cultivated grapes grow. It also extends on the north to include a considerable portion of Canada. However, the insect has not as yet, with occasional exceptions, assumed the proportions of a pest of much economic importance outside of the Central States between the latitudes of 35° and 40°.

On the accompanying map (fig. 1) are shown localities in the United States and Canada where the writer has been able to find definite

records of its occurrence. However, in States where the map shows only a single record, a search for specimens would doubtless show the species to be present generally.

FOOD PLANTS.

Desmia funeralis feeds principally on the wild and cultivated grape. It has been collected on fox grape, *Vitis labrusca;* southern fox grape, *Vitis rotundifolia;* and *Vitis cordifolia.*

Generally speaking, all varieties of cultivated grapes are liable to attack, though there is some evidence to indicate that the larvæ may show discrimination. According to Woodworth (14) this distinction made by the larvæ between varieties is quite marked, the varieties

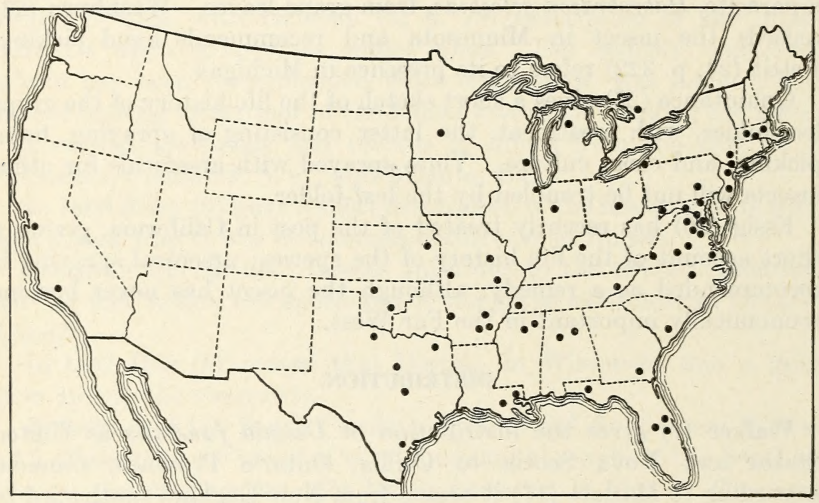
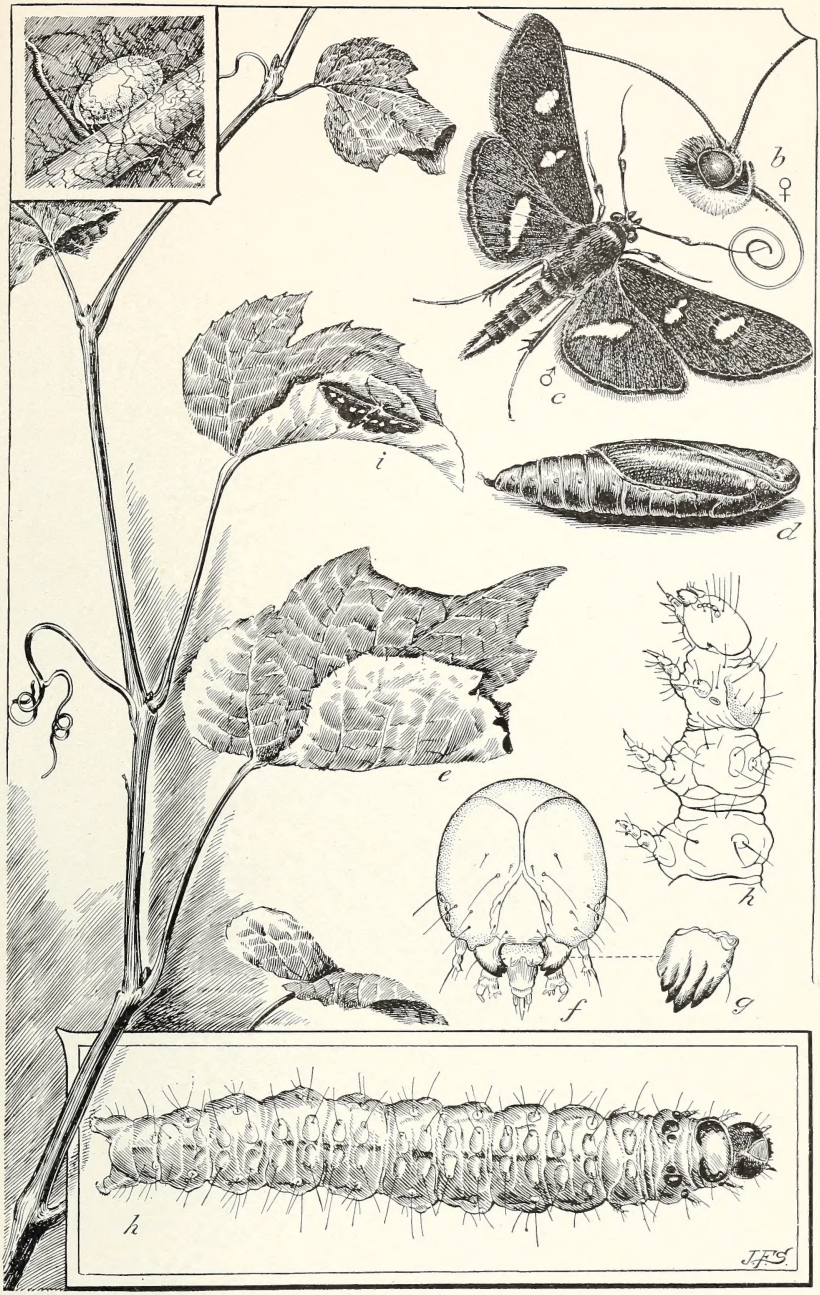


FIG. 1.—Map showing distribution in the United States of the grape leaf-folder, *Desmia funeralis.* (Original.)

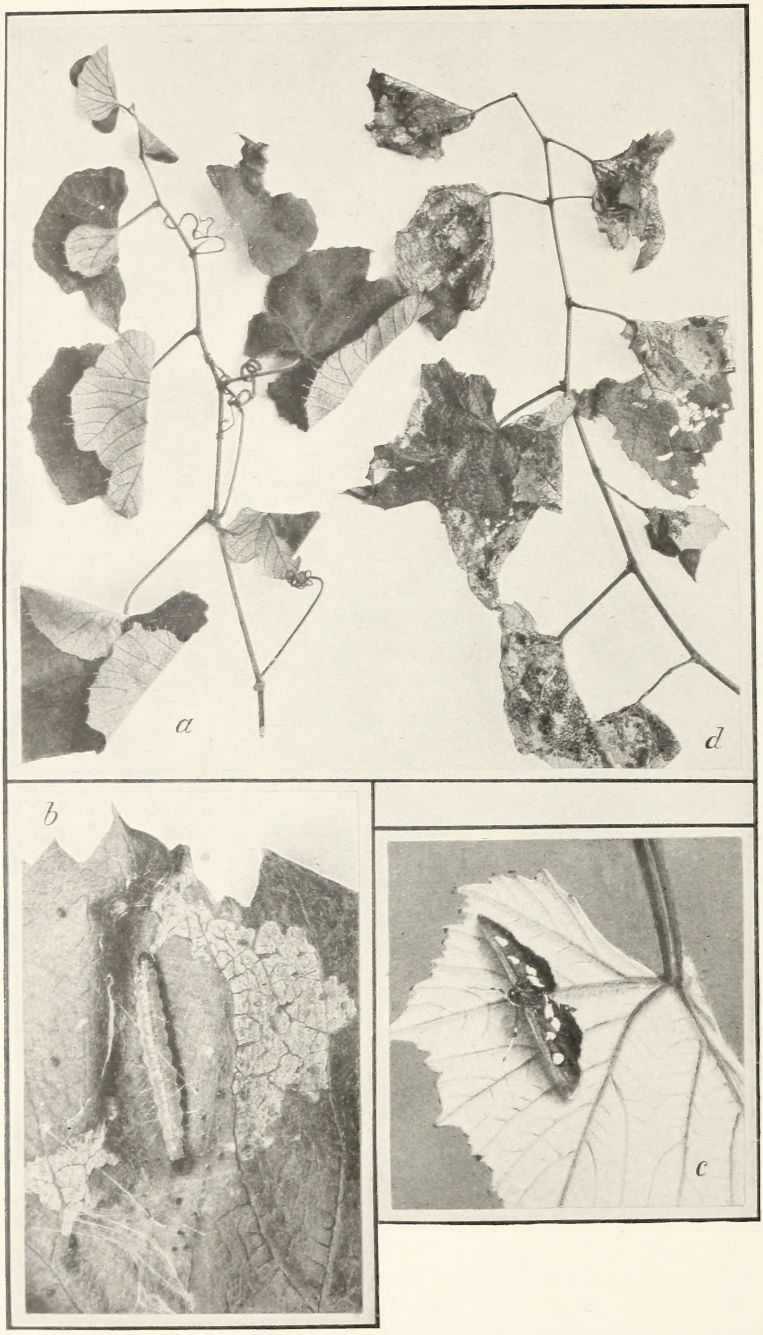
Agawam, Brighton, Excelsior, Grein's Golden, Highland, Herman, Israella, Jefferson, Jessica, Mary Ann, Lady Washington, Merrimac, Mason Seedling, Requa, Rogers, and others losing more than three-fourths of their foliage, while others lose about one-half. The writer has found in Virginia that the Clinton, Duchess, Martha, Moore's Early, and Amber varieties are particularly attractive to the insect. Varieties with tough leaves are less attractive than those with more tender foliage.

Plants other than the grape are fed upon by *Desmia funeralis,* Titus having found it on Virginia creeper (*Parthenocissus quinquefolia* [L.]) near Somerset, Md. He also found two varieties of redbud, *Cercis canadensis* and *Cercis chinensis,* as hosts, in the Department of Agriculture grounds at Washington, D. C.



THE GRAPE LEAF-FOLDER.

Life history of the grape leaf-folder (*Desmia funeralis*): *a*, Egg; *b*, head of adult female, side view; *c*, adult male; *d*, pupa; *e*, folded leaf making a retreat for larva; *f*, enlarged head of larva showing mouth parts, frontal view; *g*, enlarged mandible with which larva eats the tissues of the leaf; *h*, *h*, dorsal view of larva, and head and thorax of same, side view; *i*, moth, natural size. (Original.)



WORK OF THE GRAPE LEAF-FOLDER.

a, Grape leaves recently folded by larvæ; *b*, folded grape leaf torn open to show full-grown larva within (from life); *c*, adult on grape leaf (from life); *d*, effect on grape leaves of attack by larvæ. *a*, *b*, Reduced; *c*, *d*, somewhat enlarged. (Original.)

EXTENT AND CHARACTER OF THE INJURY.

During most years in a few localities throughout its range of distribution, this insect is quite abundant and the cause of important damage to the vine by the destruction of the foliage at a time when this is needed to ripen the fruit properly. During occasional years it may become excessively abundant and destructive, as has been the case in the environs of Washington, D. C., during the past three or four years.

The grape leaf-folder gains its title through the injury inflicted by its larvæ upon the foliage. In the experience of the writer, the direct injury is sustained by the foliage alone, although Mr. Fred Johnson has observed the larvæ of the first brood eating the blossoms and young fruit.

The injury to the leaves is very characteristic and may be easily recognized (Pl. I, *e*). As soon as the larva is large enough it folds the leaf, exposing the under surface, the edge being held in place by bands of silk thread (Pl. II, *a;* Pl. III, *a*). It is within the protection of this fold that the larva feeds, skeletonizing the leaf on the upper surface (Pl. III, *b*).

When the larvæ are numerous the injury to the vine becomes very conspicuous, even at a considerable distance, for the light color of the under surface of the folded leaves contrasts strongly with the dark green of the upper side presented normally, giving the vine a patchy appearance. Later in the season the skeletonized leaves dry up (Pl. II, *d*), exposing the fruit to the rays of the sun and, in case of a severe attack, rendering the fruit unmerchantable. The writer has observed such conditions in several vineyards in Fairfax County, Va.

In a young vineyard at Herndon Heights, Va., consisting of several acres of Concords and Niagaras, four-fifths of the foliage was found to have been destroyed. In the immediate vicinity there was an abundance of badly infested "chicken" grapes (*Vitis aestivalis*), which doubtless served to supply the insects to the cultivated vines.

The experience of a grower with the depredations of this pest at Riviera, Tex., is of interest and is presented in the following letter received by the Bureau of Entomology under date of January 15, 1915:

> This insect was much more troublesome here last year than ever before. It appeared in force just as the grapes were beginning to color or ripen, and so thoroughly stripped off the leaves that the grapes could be used only for jelly, or sauce, by cooking them green. I saved most of mine by dusting the vines with Paris green and lime in the early morning while the dew was on the leaves and the wind was calm, but the few others here who raise grapes had no ripe ones to eat or sell. The clusters hanging below the leaves (and usually getting very little dew) caught very little of the poison.

DESCRIPTION OF THE GRAPE LEAF-FOLDER.

ADULT.

The wings of the moth when fully expanded (Pl. I, *c*) measure about nine-tenths of an inch. These are very dark brown in color with an opalescent or silvery reflection, and are bordered with white. The forewings in both sexes have two nearly oval white spots, while on the hind wings of the male there is one spot, which, in the female, may be divided. The body is black, crossed by two white bands in the female and by one band in the male. The male antennæ are thickened or knotted near the middle, while in the female (Pl. I, *b*) they are uniform and thread-like.

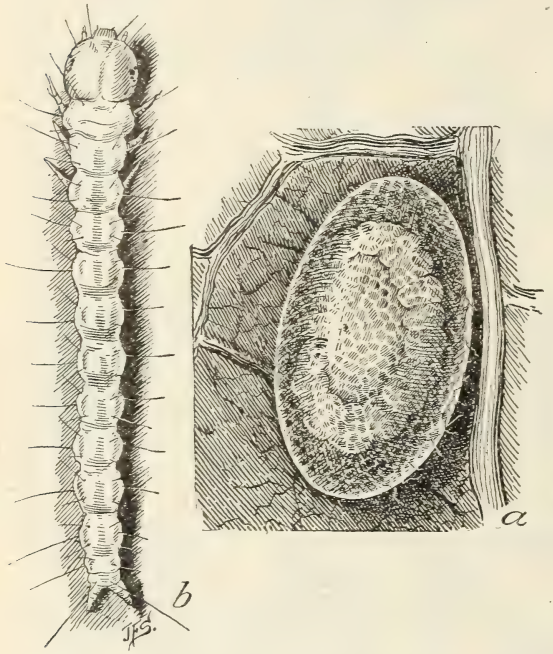


FIG. 2.—*a*, Egg of the grape leaf-folder showing larva just before hatching; *b*, newly hatched larva. Greatly enlarged. (Original.)

THE EGG.

The egg of the grape leaf-folder (fig. 2, *a;* Pl. I, *a*) is elliptical in outline and very minute, measuring about 0.7 mm. in length. Its membranous chorion, or outer covering, presents under high magnification delicate hexagonal markings.

THE LARVA.

The larva, when fully grown (Pl. I, *h;* Pl. II, *b*) is about an inch long, is widest in the middle, and tapers toward either end. It is glossy, translucent yellow-green on the sides and somewhat darker above, with scattered fine yellow hairs on each segment. The head and prothoracic shield (Pl. I, *f*, *h*) are light brown, and there are light-brown spots on the sides of the first two thoracic segments.

THE PUPA.

The average pupa of *Desmia funeralis* is a little over half an inch long (Pl. I, *d*). The light-brown color shown just after pupation soon turns quite dark. The pupa tapers characteristically toward the posterior end, where an 8-hooked cremaster is located.

LIFE HISTORY AND HABITS.

The moths of the grape leaf-folder issued in greatest numbers during the early part of May, from pupæ overwintered in jars in the out-of-door rearing shelter at Washington, D. C. This maximum-emergence date will vary, of course, with different localities, owing to variation in humidity and temperature. Moths were obtained over a much longer period, including the latter part of April, all of May, and most of June.

About 60 minutes is consumed by the insect in emerging from the pupal skin, the operation commencing with a circular abrasion at the head end. The number of females to issue was greater than the number of males by approximately seven to one. Numerous moths, both males and females, were confined in jars for several days and fed on honey and water, but at no time was mating or oviposition observed.

The adults when disturbed fly rather quickly, but as a rule they are to be found at rest on the underside of the leaves (Pl. I, *i;* Pl. II, *c*). The eggs are usually deposited singly on the underside of the leaf (Pl. I, *a*) along the midrib or other veins, or in the angles formed by the branching of the veins. The writer has found eggs scattered over the grape canes, as has been recorded, and the finding of them on the leaves has been corroborated by other observers.

The young larvæ, about one thirty-second of an inch in length (fig. 2, *b*), emerge from the eggs in 8 or 10 days, and as they are unable at this time to fold the leaves, search out a sheltered place among the foliage, or even crawl into the folded shelter made by an older larva, where they commence feeding upon the upper epidermis of the leaf.

During its life the larva molts six times, the thoracic markings becoming darker with each molt. During the periods of three or four days between molts the larva feeds almost continuously, though it is especially active at night.

When about two weeks old the larva makes a small fold in the leaf. It commences the operation by spinning strands of silk from side to side, across a portion of the leaf near the edge, each successive silken strand being shortened until the edge of the leaf is gradually drawn over and fastened with shorter bands of silk. It has been thought by some investigators that among the leaf-tying and leaf-rolling larvæ the folding and fastening of the leaf is not so much the product of actual strength exerted by the immature larva, but is the result of solidification of the newly-produced silken strands in drying. Within this shelter the larva spins a further protection, composed of many recrossed strands of silk (fig. 3). If its shelter is torn open, the larva wriggles violently and usually falls to the ground.

The attacks of a larva are not necessarily confined to a single leaf. In rearing experiments conducted in jars two leaves usually consti-

tuted the food of a single larva throughout its life. On the other hand, a single large leaf may be the object of attack of more than one larva, seven having been counted under field conditions.

In the latitude of Washington, and perhaps in most of the Northern States, there are two generations of the grape leaf-folder each year. In the Southern States it is thought that there may be three or more generations annually.

The majority of first-brood larvæ pupate during July, the average length of time passed in the larval stage being about four weeks. The full-grown larvæ leave their shelters and drop to the ground, where they transform among fallen leaves, trash, etc. In exceptional cases a larva may web several leaves together on the grapevine and pupate within this shelter, or it may even pupate within the folded leaf where it has fed.

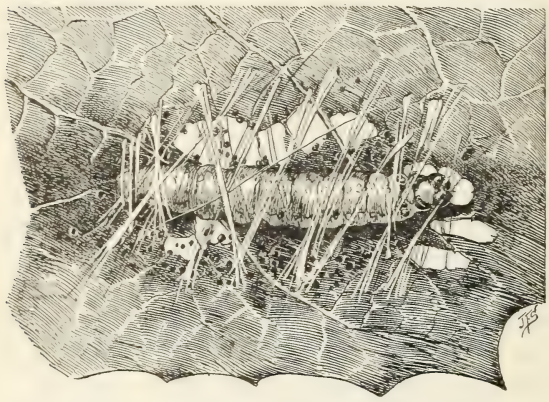


FIG. 3.—Larva of grape leaf-folder under its web on grape leaf, which has been spread open. Much enlarged. (Original.)

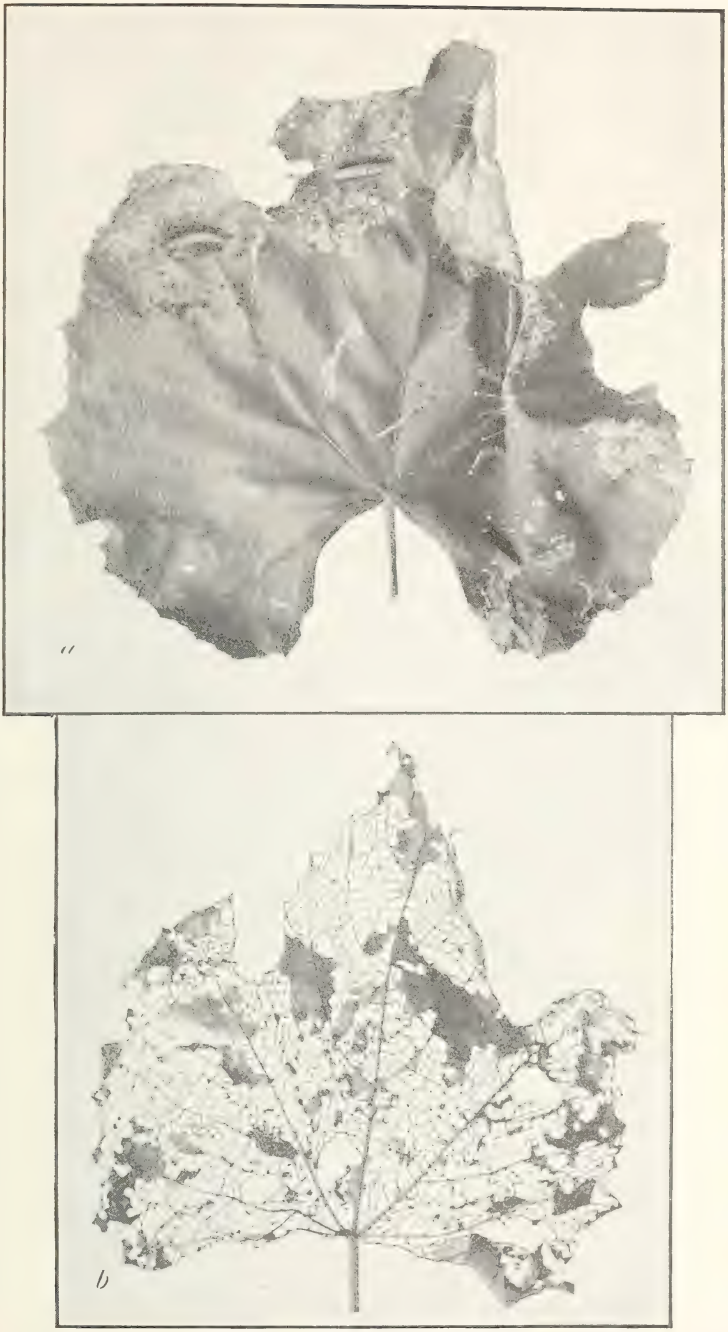
During the latter part of July and throughout August the moths are again flying and depositing eggs, from which will hatch the larvæ of the second brood.

Compared to the number of larvæ that appear in the second brood, those of the first are quite insignificant, and it is through this great increase in numbers that the injury becomes serious in late summer and fall.

These larvæ of the second brood begin to pupate in September in the latitude of Washington, and by the middle of October few, if any, are to be found in the leaves. The pupæ of this brood are also to be found among the dead leaves on the ground, and it is in this stage that they pass the winter.

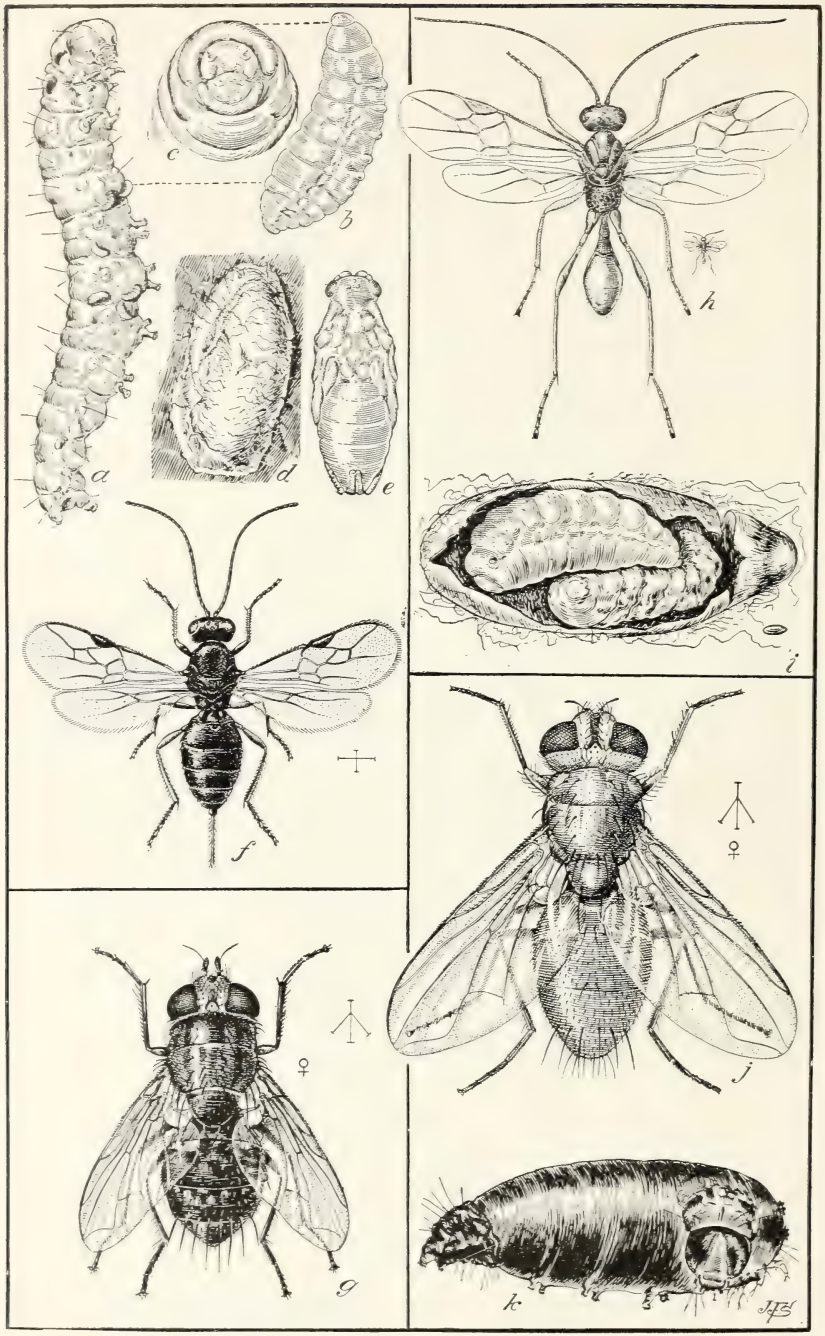
NATURAL ENEMIES.

The larvæ and pupæ of *Desmia funeralis* are preyed upon by a number of hymenopterous and dipterous parasites. These natural enemies help materially in keeping down the numbers of the pest, and are, together with other factors, responsible for the greatly diminished numbers of the overwintered pupæ, and consequently of the first brood of larvæ in the spring.



WORK OF THE GRAPE LEAF-FOLDER.

a, Grape leaf attacked by leaf-folder, several folds being torn open to show larvæ; *b*, grape leaf skeletonized by larvæ. (Original.)



PARASITES OF THE GRAPE LEAF-FOLDER.

a, Newly hatched larvæ of *Habrobracon johannseni* feeding on larva of grape leaf-folder; *b*, Habrobracon larva, more enlarged; *c*, head of Habrobracon larva, still more enlarged, showing rudimentary antennæ; *d*, Habrobracon cocoon on portion of grape leaf; *e*, ventral view of pupa of Habrobracon; *f*, adult Habrobracon; *g*, *Exorista pyste*; *h*, *Meteorus dimidiatus* (natural size at right); *i*, *Perilampus platygaster*, an internal hyperparasite attacking Meteorus larvæ in Meteorus cocoon; *j*, *Leskiomima tenera*, adult; *k*, puparium of Leskiomima, showing remains of chitinized parts of grape leaf-folder. Much enlarged. (Original.)

Following is a list of parasites of *Desmia funeralis* reared by the writer:

HYMENOPTERA.

Apanteles canarsiae Ashm.
Habrobracon johannseni Vier.
Meteorus dimidiatus Cress.
Pardianlomella ibseni Gir.
Trichistus pygmaeus Cress.
Mesochorus scitulus Cress.
Gemocerus sp.

DIPTERA.

Tachinophyto variabilis Coq.
Exorista pyste Walk.
Leskiomima tenera Wied (Pl. IV, *j*, *k*).

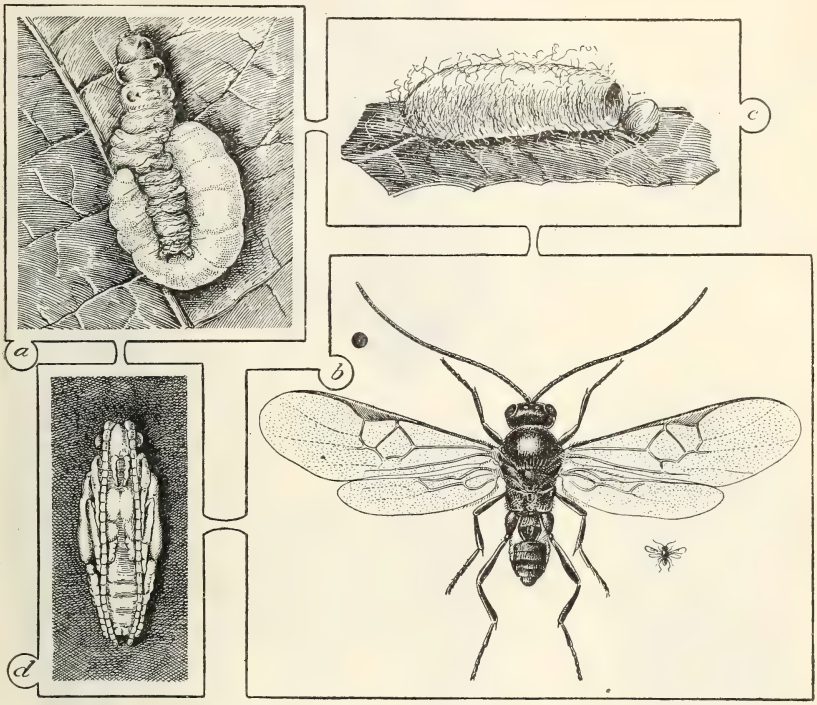


FIG. 4.—*Apanteles canarsiae*, a parasite of the grape leaf-folder: *a*, Apanteles larva feeding on grape leaf-folder larva; *b*, adult Apanteles (natural size at right below); *c*, cocoon of same; *d*, pupa of same. Much enlarged. (Original.)

The following notes were made on the life histories of several of the foregoing species during the course of the study.

Several individuals of *Apanteles canarsiae* Ashm. (fig. 4) were found in considerable numbers. Their small white cocoons were quite abundantly scattered over the larval webs of Desmia during the latter part of August and the first of September. The minute, sluglike larvæ of the parasite feed externally, a single individual completely consuming the soft parts of its host. When fully grown the larva crawls some distance from the remains of its host, and within an hour

has constructed its cocoon, within which pupation takes place (fig. 4, *c*). In about five days the adult Apantales issues.

Meteorus dimidiatus Cress. (Pl. IV, *h*) was found reasonably abundant in one locality in Virginia. It attacks the Desmia larvæ during the early autumn. When full grown the larva spins an oval brownish cocoon 4 or 5 mm. long, which it fastens down to the grape leaf with

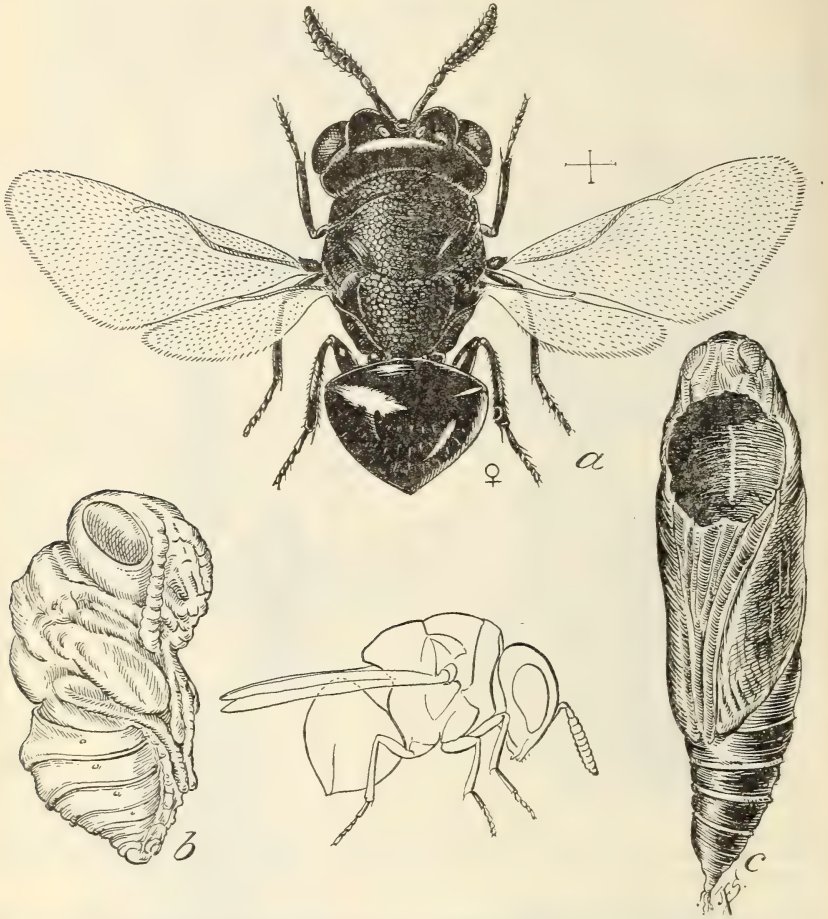


FIG. 5.—*Perilampus platygaster*, a parasite of *Meteorus dimidiatus*, which in turn is a parasite of the grape leaf-folder: *a*, Adult female (profile view below); *b*, pupa of same; *c*, pupa case of grape leaf-folder from which adult Perilampus issued. Greatly enlarged. (Original.)

silk threads. Numerous adults were reared during September from cocoons collected on grape leaves. This species is itself parasitized, *Perilampus platygaster* Say having been found attacking it in both the larval and pupal stages (fig. 5; Pl. IV, *i*).

On September 27 several eggs of a new species of eulophid, *Pardianlomella ibseni* Gir. (fig. 6) were found scattered over the web and body

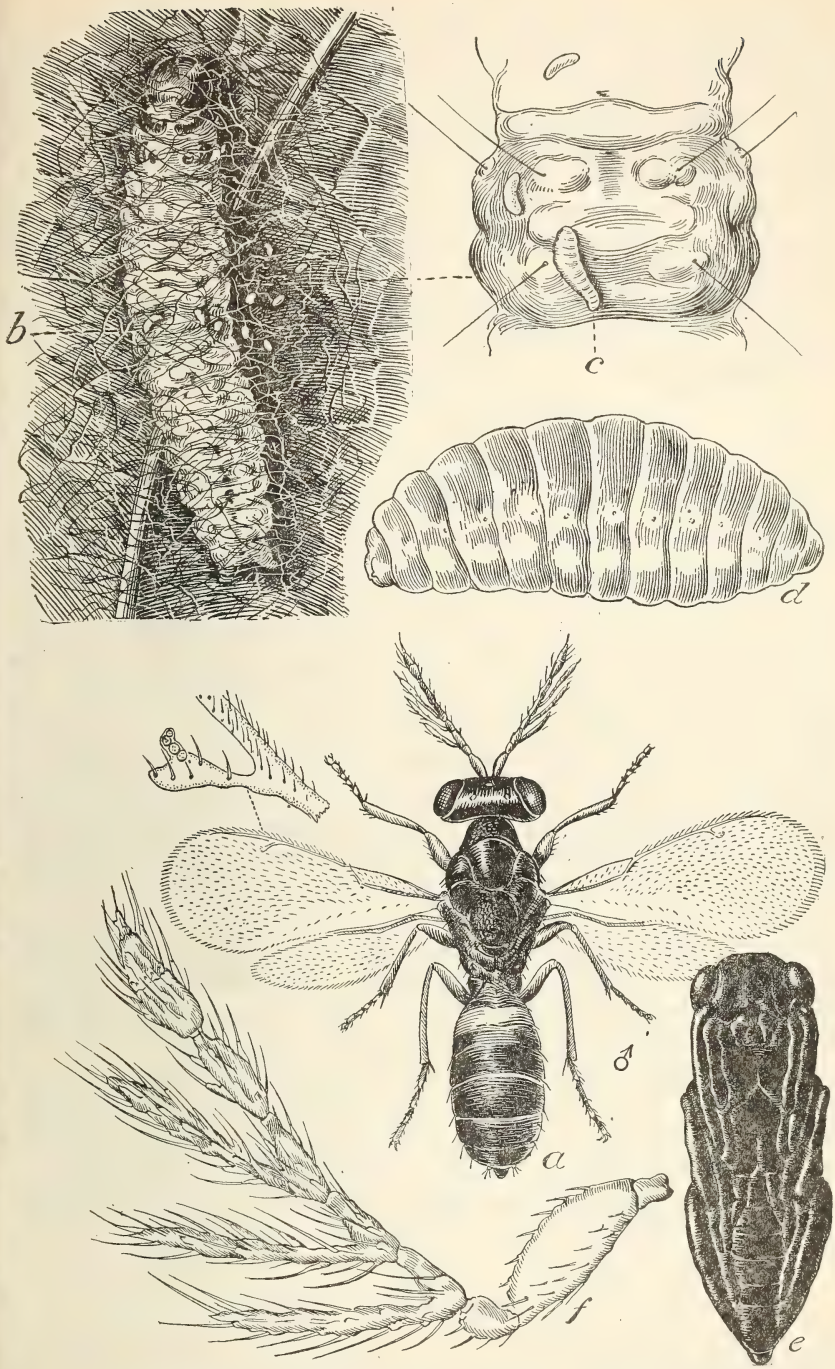


FIG. 6.—*Pardianlomella ibseni*, a parasite of the grape leaf-folder: *a*, Adult male; *b*, eggs of *Pardianlomella ibseni* on leaf-folder larva; *c*, egg and newly hatched feeding larva on segment of leaf-folder larva; *d*, larva of Pardianlomella, full grown; *e*, pupa of same; *f*, antenna of adult, highly magnified. All much enlarged. (Original.)

of a larva of the grape leaf-folder. These eggs hatched the following day, and the active little parasites greedily attacked their host, feeding externally, their mouth parts embedded in the soft tissues. In five days they left the remains and pupated. The pupæ at first were milk white, but later turned black. These pupæ overwintered in jars, and on May 30 of the following spring the adults issued (fig. 4, *d*).

Habrobracon johannseni Vier. (Pl. IV, *a–f*), a new species of braconid, was found widely distributed. It feeds externally upon the Desmia larvæ.

The fly parasites of the grape leaf-folder were taken only in small numbers. The most abundant of the three species was the tachinid *Exorista pyste* Walker (Pl. IV, *g*).

METHODS OF CONTROL.

Vineyards regularly sprayed with arsenicals for the control of the grape rootworm, grape-berry moth, etc., will be practically free from injury by the grape leaf-folder. The insect is especially likely to cause injury in small vineyards not regularly sprayed and to grapes grown in arbors in backyards and similar places.

Where the insect has been troublesome in previous years, the vines should be well sprayed with arsenate of lead at the rate of 2 pounds of the paste or 1 pound of the powdered article to 50 gallons of water, shortly after the blossoms have fallen. One treatment at this time, if thoroughly made, should destroy the caterpillars of the first brood so effectually that injury by second-brood larvæ would be of little importance. If the caterpillars continue troublesome, however, additional applications should be made. Arsenicals are usually applied to grapes in fungicides, as in Bordeaux mixture for the control of fungous diseases. Information on the general subject of spraying grapes is contained in Farmers' Bulletin 284, United States Department of Agriculture. For small spraying operations, as in back yards, a very simple spraying outfit may be employed, such as a bucket pump or knapsack pump.

Where it is impracticable to spray the vines, it will be decidedly advantageous to go thoroughly over the plants when the folded leaves are in evidence and crush the larvæ by hand. As an additional method of reducing injury it is advisable to rake together and burn fallen foliage in the fall, since the insect passes the winter in the pupal condition in these leaves.

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